PROVINCE OF ALBERTA

REGULATIONS

FOR THE

CONSTRUCTION AND INSPECTION

OF

BOILERS

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OF

BOILERS

ISSUED BY AUTHORITY OF THE
HON. A. L. SIFTON, PREMIER OF ALBERTA
AND MINISTER OF PUBLIC WORKS.
JANUARY 1ST, 1911.

All Regulations previously issued for the Construction and Inspection of Steam Boilers for the Province are hereby superseded

Copies of these Regulations can be obtained on application to the Steam Boiler Branch, Edmonton.

EDMONTON:
James E. Richards, Government Printer.
1911

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REGULATIONS

GOVERNING THE

CONSTRUCTION AND INSPECTION OF BOILERS

FOR THE PROVINCE OF ALBERTA.

I.—GENERAL.

These Regulations are in effect from the date of issue, January 1st, 1911. They are very similar to the 1910 Regulations, except that certain ambiguous clauses in the latter have been made clear.

1.—Designs Already Registered.

It will not be necessary for new drawings and specifications to be submitted under the 1911 Regulations for designs already submitted, approved and recorded by the Department under the 1910 Regulations, except in specific cases, when a special request will be made by the Department.

2.—Second-hand Boilers.

Boilers entering the Province as settlers' effects, and not built in accordance with these regulations, shall be rated by the formulae herein stated, and their working pressure reduced at least 10 per cent. below the limit as found by the formulae, if deemed necessary by the Inspector. They must be equipped with fittings, etc., according to the Act and regulations. The right is reserved to reduce the pressure of any boiler to what is considered a safe limit.

3.—Maximum Pressure for Traction and Portable Boilers.

The safety valve of any traction or portable boiler shall not be set at a greater pressure than 175 pounds, notwithstanding the calculated working pressure of the boiler, and no exception will be made to this ruling. If, for instance, however, the calculated working pressure of a traction or portable boiler is 200 pounds, and a reduction of pressure is made by reason of inferior workmanship or material or other defects, the reduction will be made from 200 pounds.

4.—Affidavit to Accompany Boiler.

When any Boiler is shipped into the Province, it shall be accompanied by a copy of approved specifications and affidavit of boiler shop foreman, under whose supervision the boiler was built, fully filled out and detailed as per the following forms:

Form 18.—Specification Forms to accompany Drawings submitted for approval.

Form 18*a*.—Specification Forms and Affidavit of Construction for locomotive type boilers (this form fully completed to be mailed to purchaser upon shipment of boiler).

Form 18*b*.—Specification Forms and Affidavit of Construction for horizontal tubular type boilers (this form fully completed to be mailed to purchaser upon shipment of boiler).

Form 18*c*.—Specification Forms and Affidavit of Construction of internal furnace tubular type boilers (including vertical type), (this form fully completed to be mailed to purchaser upon shipment of boiler).

Form 18*d*.—Specification Forms and Affidavit of Construction of water tube boilers (this form fully completed to be mailed to purchaser upon shipment of boiler).

The above Forms are printed by the Department, and will be supplied to manufacturers upon request.

When the Inspector has noted this affidavit and specifications and compared the same with the boiler, he must file the same with the Department.

5.—Fees for Survey of Drawings, Etc.

The fees for surveying Designs or Revisions of Designs of Boilers and Accessories for approval and registration shall be as follows:

Vertical Tubular	$5.00
Horizontal Tubular up to 42 in. in diameter	5.00
Horizontal Tubular over 42 in. in diameter	10.00
Return Tubular	10.00
Internal Furnace Tubular	10.00
Locomotive Firebox	10.00
Water Tube	10.00
Power Plant Piping up to 500 horse power	5.00
Power Plant Piping from 500 to 1,000 h.p.	7.50
Power Plant Piping over 1,000 horse power	10.00
Boiler Accessories, such as Safety Valves, Stop Valves, Steam Gauges, etc., for each design	3.00

Special Note: Fees must accompany Drawings when the latter are submitted to the Department for approval.

II.—REGISTRATION OF DESIGNS.

6.—Drawings and Specifications.

Before commencing work on any boiler to be built under these Regulations, three drawings of the same, with specification form in duplicate, must be submitted to the Department for approval of the pressure and arrangement of the Boiler, which must comply in all cases with these Regulations and the Act.

This applies also to designs for safety valves and other fittings connected immediately to the boiler, such as stop valves, water gauges and cocks, pressure

gauges, and blow-off valves. Approval or corrections will promptly be given, or pointed out in the order as applications are received by the Department, and the manufacturers advised accordingly.

Each Drawing must show all details and complete dimensions, the material and sizes also being given on specification.

To prevent delay, any manufacturer must submit for approval, designs of manufacture which, when finally approved, will be given registration numbers for the Province, and from which boilers may be made by that manufacturer in any number, full reference being made to the registration when sworn construction Certificates are sent to the Department concerning such boilers. Any new design submitted for approval after any change in these regulations has been made must be in accordance with such change.

Three drawings or blue prints of each design submitted must accompany an application for its approval each having a blank or white space on it, three by four inches in size; one of these drawings will be returned to the manufacturer. Changes in design necessitate submission of new Drawings and Specifications for approval and fresh registration.

When a design is approved, the Department will allot to the manufacturer a registration number for that particular design.

It is to be understood that the approval of Drawings will not exonerate the manufacturer from any responsibility in connection with boilers and fittings constructed according to these Regulations.

7.—Identification.

Every boiler built under these regulations shall be stamped on the plates of the boiler on the place hereafter indicated, as follows, in figures at least one-quarter of an inch in size:

(*a*) Builder's name and number of boiler.

(*b*) Provincial letter and registration number of design.
(*c*) Lowest tensile strength of any shell plate in the boiler, with "S" for steel and "I" for iron.
(*d*) The name of the plate manufacturer.
(*e*) The date of construction, thus: Day of month, numerical order of month, last two figures of year.

A sample stamping would be as below, it being stamped legibly and fully into the plate of the boiler itself (not the smoke box):

(*a*) Name in full. 777.
(*b*) A. 555 (for Alberta).
(*c*) 55000. S.
(*d*) Name in full.
(*e*) 26.10.10.

The locations of stamping shall be as follows:

On horizontal return tubular boilers, on centre of front head above tubes.

On portable and locomotive types, on right side of fire door, clear of attachments.

On water tube boilers, on the end of steam drum above manhole door.

On internally fired boilers with circular furnaces, on right side of fire doors, if practicable.

On vertical boilers, on right side of fire door.

For Boilers where location is not practicable as above, it must be indicated in specification.

All new heating boilers must be stamped "For heating purposes only," on front head above tubes, or any conspicuous place on the shell.

III.—DESIGN.

8.—Cylindrical Portions of Boilers.

Cylindrical portions of boilers, such as shells or barrels, domes, drums or reservoirs, shall be made as nearly as possible truly cylindrical.

All surfaces formed to a true circular curve, except in surfaces otherwise provided for, shall be calculated in a similar manner to cylindrical shells, but when they or other parts are not so made, or are parts of true cylinders of different radii, they must be treated as flat surfaces, and stayed accordingly, and in any case at the change of curvature.

9.—Thickness of Plates.

The minimum thickness of any plate used in the construction of a boiler under these regulations shall be one-fourth ($\frac{1}{4}$) of an inch, and in all cases the thickness of boiler heads having a diameter up to 40 inches shall not be less than 5/16 inches; diameters over 40 inches and up to 52 inches, not less than 3/8 inches; diameters over 52 inches and up to 60 inches, not less than 7/16 inches, and not less than 1/16 inch additional thickness for every six inches additional diameter for boilers above 60 inches diameter.

The thickness of all plates in cylindrical portions of shells or drums shall be alike, and that required for the working pressure of any part according to formula hereafter given, but must not be less than one-quarter inch.

The minimum thickness of plates in stayed surface construction shall be five-sixteenths (5/16) of an inch.

10.—Maximum Diameter of Boiler.

Seventy-two inches shall be the maximum diameter for all externally fired boilers.

11.—Reinforcing Plates.

(*a*) For standard pipe connections below water line exceeding ¾ inch diameter, and not exceeding two inches in diameter, and for standard pipe connections above water line exceeding one inch in diameter and not exceeding two inches in diameter, the openings in boiler shall be reinforced with a plate securely riveted to the shell, the threads being made continuous and full size through both plates, and the pipe fitting tightly in both.

(*b*) Instead of the reinforcing plates required by the above clause, forged steel flanges, threaded to receive the pipe, may be used, except at blow-off outlet, and must be riveted to the outside of shell. The threaded portion for pipes up to 1¼in. bore shall have a depth of not less than one inch; for pipes 1½ in. bore the depth shall be not less than 1¼ in.; and for pipes up to two inches bore the depth shall be not less than 1½ inches. The thickness of flange for pipes up to 1¼ in. bore shall be not less than 5/16 inch, and for pipes exceeding 1¼ inch bore and up to two inches bore shall be not less than ⅜ inch thick. Opening in boiler shell shall be not more than ¼ of an inch greater in diameter than the bore of the flange.

(*c*) For all connections exceeding two inches in diameter, except at blow-off outlet, flanged nozzles riveted to the boiler must be used. For working pressures exceeding one hundred pounds per sq. inch the nozzles must in all cases be of steel. In traction boilers, steel flange bases riveted to the boiler may be used instead of flanged nozzles for connections up to and including 3 inches in diameter.

(*d*) Other openings in cylindrical parts of boilers, drums or other parts shall be reinforced in all cases when their measurement exceeds $2\frac{1}{2}'' \times 3\frac{1}{2}''$.

(*e*) All openings in flat or cambered surfaces of boilers, drums or other parts exceeding $2\frac{1}{2}'' \times 3\frac{1}{2}''$ shall be reinforced or flanged inwards.

All reinforcing rings or plates must be fitted closely to the plates they reinforce, and at least the same thickness.

12.—Reinforcing Plates Where Brackets are Attached.

Where brackets or other fixtures subjected to any working strain are attached to a traction or portable boiler, the plates to which these brackets are attached shall be reinforced with plates of the same thickness as the outer plates, and properly riveted together. The outer rows of rivets attaching reinforcing plates must be outside the bracket. All brackets shall be properly fitted (without white metal or other filling) to the plates, flat or curved, with stud holes drilled to suit the holes in brackets, which must be drilled to templates and tapped 12 threads per inch. The use of cap screws will not be permitted for this purpose.

(*a*) Providing the shell plates throughout are not less than one-half inch in thickness, the reinforcing plates referred to in the preceding paragraph may be omitted.

13.—Manholes.

All boilers shall be provided with the prescribed number of manholes of standard size, strengthened with reinforcing ring cut from boiler plate of at least the same thickness as the shell, and equal, exclusive of rivet holes, to the area of section cut from shell in line with its longitudinal axis, riveted around the manhole opening.

A flange formed inwards on the reinforcing plate to receive the door is required. The reinforcing plate must be placed on the inside of boiler, except in boilers under forty-two (42) inches diameter, when it may be placed outside.

All manholes in flat surfaces must be flanged from solid plate inwards.

All manhole flanges must have a ring not less than three-quarters ($\frac{3}{4}$) of an inch by one and one-half ($1\frac{1}{2}$) inches securely shrunk around flange, which shall be faced to form a joint.

The rivets holding reinforcing rings to shell must be sufficient for caulking purposes, but their area in no case shall be less than one hundred and twenty per cent. (120%) above the net sectional area of part cut from shell in line of its longitudinal axis.

14.—Location of Manholes.

There shall be a standard manhole in the upper part of the shell of a fire-tube boiler 42 inches and above in diameter, excepting vertical fire-tube boilers, where the furnace or tubes prevent access to the interior of the boiler.

(*a*) Horizontal cylindrical boilers 48 inches in diameter and upwards shall contain two manholes not less than 10 inches by 15 inches in the clear, one in the front head below the tubes, and one in the shell above the tubes. In boilers sixty-six (66) inches and above in diameter, manholes shall be twelve inches by 16 inches in the clear.

15.—Manhole and Handhole Doors, Bolts and Bridges.

Manhole doors must be well fitted and faced off. The possible lateral motion in no case exceeding one-eighth ($\frac{1}{8}$) inch. Cast iron manhole doors of good design, and material, may be used for boilers carrying a pressure not exceeding one hundred (100) pounds. Doors not exceeding twelve (12) inches by sixteen

(16) inches to be made of steel plate at least one inch thick, or of approved pressed steel design five-eighths (⅝) inch thick, for pressures from one hundred (100) pounds to one hundred and twenty-five (125) pounds inclusive; and from one hundred and twenty-five (125) pounds to two hundred (200) pounds pressure inclusive, these shall not be less than one and one-eighth (1⅛) inches and eleven-sixteenths (11/16) inch thick respectively. If two flat plates riveted together are used for manhole doors, the plate forming flange must be not less than ¾ inch thick, and the thickness of the two plates must be not less than 1″ and 1⅛″ respectively. The plates must be well riveted together.

(*a*) Manhole doors are to be provided with two bolts at least one and one-quarter inches (1¼) in diameter, having a shoulder on the outside, screwed through the door and riveted to the inside. For pressed steel doors less than ¾″ thick, the bolts must be screwed through the door, nutted and riveted over.

(*b*) For working pressures up to one hundred pounds inclusive, cast iron handhole doors may be used when of good design and material, and may be made of cast malleable for pressures exceeding one hundred pounds when not over two and one-half (2½) by three and one-half (3½) inches. When exceeding two and one-half (2½) by three and one-half (3½) inches, and a pressure of over one hundred (100) pounds is carried, steel plate doors must be used, the thickness of door flange to be at least the thickness of surrounding shell plate.

(*c*) Handhole door bolts must be not less than three-quarters (¾) of an inch in diameter, for doors two and one-half by three and one-half (2½ x 3½) inches, and at least seven-eighths (⅞) inch when exceeding that size, all bolts being screwed through the door and riveted to the inside.

(*d*) All bridges used for manhole and handhole doors must be wrought-iron or of pressed steel design, and of ample strength to withstand the stress put

upon them. Bridges used for doors not exceeding two and one-half by three and one-half ($2\frac{1}{2}$ x $3\frac{1}{2}$) inches may be cast malleable iron.

16.—Handholes and Washout Plugs.

All cylindrical horizontal boilers less than 42 inches in diameter must be provided with a handhole in each head below the tubes not less than three by four and one-half (3 x $4\frac{1}{2}$) inches, which must be flanged inwards or reinforced.

All other types of boilers must be provided with sufficient mud-hole or handhole and washout plug openings to provide for properly cleaning and inspecting every part of the boiler. When mudhole openings are threaded for plugs, the plugs must in all cases be of brass.

17.—Handholes and Washout Holes in Loco Type.

A locomotive type boiler shall be provided with sufficient handholes and washout plugs to allow the whole of the interior to be inspected and for washing out.

In no case shall there be less than six handholes, or less than twelve such openings in all, the whole to be located as approved in design, and due regard had to facility of access when the machinery or other attachments are mounted on the boiler, great care being taken to secure the best arrangement for cleaning the interior of the boiler. Wet bottom boilers must have a plug in the lowest part of shell, and have a drainage tube in bottom to drain ashpan.

18.—Firehole Doors.

Fireholes in portable, traction and locomotive firebox boilers and in vertical boilers exceeding thirty inches diameter, must not be less than 10 inches by

15 inches, or equivalent area if the maximum dimension is not less than fourteen (14) inches in the clear, to allow for examination of firebox.

19.—Handholes in Vertical Boilers.

All vertical fire-tube boilers shall have not less than seven (7) openings for cleaning out purposes, located as follows: One (1) at the water line four inches by six inches, three (3) in line with the lower tube sheet, two (2) at bottom of water leg, one (1) small plug under firehole door. Boilers exceeding 36 inches in diameter shall contain two (2) four by six (4 x 6) inch handholes located at the water line placed opposite to one another.

20.—Minimum Diameter of Stay.

No stay less than seven-eighths ($\frac{7}{8}$) inch, as measured over the threads, shall be used in the construction of any boiler.

21.—Screwed Stays to Have Substantial Heads.

Screwed stays (not fitted with nuts) must be thoroughly fitted to the sheets, be well set up, and the ends well riveted over, to form good substantial heads, but standing not more than two and one-half or less than two threads above the sheet at their centre. The number of threads per inch shall not exceed twelve, or be less than eleven in any plate or shell in a boiler, except for standard steam and water pipe sizes. The use of the Whitworth type of thread is recommended. Where stay nuts are used they must have true and smooth bearing on the sheets, or washers when brought up.

22.—Maximum Working Stress on Stays.

The maximum working stress on stays shall be as follows:

(*a*) Iron. For screw stays and other stays which have been welded, 5,000 pounds per square inch net section will be the maximum stress allowed. For screw stays and other stays not welded, 7,000 pounds per square inch net section will be the maximum stress allowed.

(*b*) Steel. For screw stays and other stays less than one and one-half (1½) square inches net sectional area, 8,000 pounds per square inch will be the maximum stress allowed. For all other stays 9,000 pounds per square inch net section will be the maximum stress allowed.

(*c*) Steel stays may be upset at ends, but not welded in any way. Longitudinal stays must be secured to heads by nuts and washers, and not riveted over on the sheets, excepting that, when the ends of longitudinal stays, if secured by nuts and washers, would be exposed to the action of the fire, as in the case of back ends of longitudinal stays below the flues of horizontal tubular boilers, they may be attached to angles, stay-plates, or tee bars riveted to the boiler head, having an ample water space between them and the head of the boiler.

Holes in the sheets for stays not screwed into or riveted to plates must not be more than one-sixteenth (1/16) of an inch larger than the diameter of the stay, and drilled to size.

Stays must be arranged so as to admit of free access to the interior of the boiler.

23.—Working Stress on Studs and Bolts.

Maximum stress on studs and bolts used for dome covers, flanges and accessories, will be taken as follows:

Dia. of Bolt or Stud	Allowable Stress
$\frac{3}{4}$ inch	3,000 pounds per sq. in.
$\frac{7}{8}$ inch	4,000 " "
1 inch	5,000 " "
$1\frac{1}{8}$ inches	5,500 " "
$1\frac{1}{4}$ inches	6,000 " "
$1\frac{3}{8}$ inches	6,500 " "
$1\frac{1}{2}$ inches	7,000 " "

Studs screwed into plain flanges, etc., must be tapped in to a depth of not less than the diameter of the stud.

24.—Domes on Cylindrical Parts of Boilers and Openings for Other Purposes.

Any opening for domes, manholes, handholes or for other purposes on shells or cylindrical parts of boilers must have its shorter axis in line with the longitudinal axis of the same, and when that is over two and one-half inches, be reinforced by a plate riveted after careful fitting to the shell, around the opening. The reinforcement must be equal in cross section and strength exclusive of rivet holes, to the section of plate cut out of shell or covered by the dome in line with its longitudinal axis. The combined area of rivets securing the reinforcement to shell must be, exclusive of those necessary to hold dome to shell, one hundred and twenty (120) per cent. in excess of the area of section so removed or measured.

25.—Maximum Working Pressure Allowed on a Boiler.

The maximum working pressure to be allowed on the shell of a boiler constructed of steel or wrought iron shells or drums, shall be determined from the minimum thickness of the shell plates, the lowest tensile strength stamped on the plates by the plate manufacturers, or as established by authoritative test, the efficiency of the longitudinal joint, or ligament

between the tube holes, whichever is the least, the inside diameter of the outside course, and the lowest factor of safety allowed by these Rules, the formula being:

$$B = \frac{2\ T \times TS \times K}{Dr \times F}$$

B = Maximum allowable working pressure in lbs., per square inch.
T = Minimum thickness of shell plates in inches.
TS = Tensile strength of plate in pounds per sq. in.
K = Efficiency of longitudinal joint, or ligament between the tube holes, the lesser of the two to be taken.
Dr = The inside diameter of the outside course of the shell or drum expressed in inches.
F = Lowest factor of safety allowed by these regulations.

26.—Efficiency of Ligament.

When a shell or drum is drilled for tube holes in a line parallel to the axis of the shell or drum, the efficiency of the ligament between the tube holes shall be determined as follows:

(a) When the pitch of tube holes on every row is equal, the formula is:

$$\frac{P_1 - dr}{P_1} = \text{Efficiency of ligament.}$$

P_1 = Pitch of tube holes in inches.
dr = Diameter of tube holes in plate in inches.

(b) When the pitch of tube holes on any one row is unequal, but pitched in regular sequence, the formula is:

$$\frac{P_2 - n_2\ dr}{P_2} = \text{Efficiency of ligament.}$$

P_2 = Unit length of ligament.
n_2 = Number of tube holes in length P_2.

dr= Diameter of tube holes in plate in inches.

(c) When a shell or drum is drilled for tube holes in a line diagonal with the axis of the shell or drum, and when the pitch of the holes in every row is equal, the efficiency of the ligament between the tube holes shall be determined as follows:

$$\frac{P_3 - dr}{P_3 \times \text{Cos} \curvearrowright}$$

P_3 = Diagonal pitch of tube holes in plate in inches.
dr= Diameter of tube holes in inches.
$\curvearrowright$ = Angle of inclination of tubes to the longitudinal axis of shell or drum.

27.—Factors of Safety.

Boilers well constructed and made of good material, shall be allowed a higher working pressure than boilers inferior in these respects.

When cylindrical shells of boilers are made of the best material (either iron or steel), with all holes drilled in place from the solid plate, the plates afterwards taken apart and the burrs removed, and all longitudinal seams fitted with double butt straps, each at least five-eighths the thickness of the plates they cover, the seams being double-riveted with rivets having an allowance of not more than 75 per cent. over the single shear, and having the circumferential seams constructed so that the percentage is at least one-half that of the longitudinal seams, and provided that the boiler has been inspected by inspectors authorized by the Act during the whole period of construction, in accordance with these Regulations, then 4.5 may be used as a factor of safety. But when the above conditions have not been complied with, the additions in the following scale must be added to the factor of safety, according to the circumstances of each case.

To be Added to Factor of 4.50.

(*a*) .10 holes in longitudinal seams, fair and good, but drilled from solid out of place after bending edges of plates.

(*b*) .20 holes in longitudinal seams, fair and good, drilled from solid out of place before bending edges of plates.

(*c*) .20 holes in longitudinal seams, fair and good, punched after bending edges of plates and reamed after assembling.

(*d*) .30 holes in longitudinal seams, fair and good, punched before bending edges of plates and reamed after assembling.

(*e*) .07 holes in circumferential seams, fair and good, drilled from solid out of place after rolling plates.

(*f*) .10 holes in circumferential seams, fair and good, drilled from solid out of place before rolling plates.

(*g*) .10 holes in circumferential seams, fair and good, punched after rolling plates and reamed after assembling.

(*h*) .15 holes in circumferential seams, fair and good, punched before rolling plates and reamed after assembling.

(*i*) .70 in longitudinal seams, if double butt straps are not fitted, and the said seams are lapped and double riveted.

(*j*) .50 in longitudinal seams, if double butt straps are not fitted and the said seams are lapped and treble riveted.

(*k*) .60 in longitudinal seams, if only single butt straps are fitted and the said seams are double riveted.

(*l*) 1.00 in longitudinal seams, when any description of joint is only single riveted, or when double butt straps are used, and only one row of rivets is in double shear.

‡(*m*) .50 holes or rivets in longitudinal seams not fair or not good.

‡(*n*) .20 holes or rivets in circumferential seams, not fair or not good.

(*o*) .40 holes in any seams not properly spaced in crossing.

‡(*p*) .40 when material is doubtful, and not properly stamped, in accordance with these regulations.

‡(*q*) .50 if joints are not close fitting, the plates being open when boiler is finished, or workmanship unsatisfactory.

(*r*) .50 if boiler has not been inspected by inspectors authorized by the Act during the whole period of construction, in accordance with these regulations.

Where marked ‡ the inspector may, according to circumstances, increase the factor given, and in the event of satisfactory information not being obtainable, the inspector shall use a basic factor of safety of five, with such additions as his judgment may dictate.

In the foregoing (*a*), (*b*), (*c*), (*d*), (*e*), (*f*), (*g*), (*h*) must be used separately, but may be added, when justified, to either (*i*), (*j*), (*k*), (*l*), (*m*) or (*n*), separately, and to (*o*), (*p*), (*q*), or (*r*) separately, or to the whole four latter when calculating the efficiency of a joint.

(*s*) Where any boiler has been subjected to overheating, strained by forcing, crystallized by age or otherwise impaired, the factor of safety expressed in section 22 shall be increased according to the discretion of the inspector.

Nothing in the Regulations shall be construed as requiring the Department to provide for the inspection of boilers outside of the Province.

28.—Maximum Pitches for Riveted Joints.

$$pM = (C \times T) + 1\tfrac{5}{8}.$$

When—

T = Thickness of plate in inches.

pM = Maximum pitch of rivets in inches immediately inside the caulking edge or edges.

C = Constant applicable from the following table:

No. of rivets in one pitch, p, (a) (b) (c) (d) and in one pitch $\frac{p}{2}$ joint (e) Sec. 27	Constant For Lap Joint	Constant for Dble. Butt Strap Joints
1	1.31	1.75
2	2.62	3.50
3	3.47	4.63
4	4.14	5.52
5	....	6.00

When work is first-class, such pitches may be adopted, so far as safety is concerned, yet, in some cases, it may not be well to adopt the greatest pitch found by the formula. The maximum pitch should not exceed ten inches, with the thickest plates for boiler shells.

29.—Lap Outside Rivets.

The lap outside rivets measured from the rivet hole to edge of plate must be at least equal to diameter of rivet hole.

30.—Minimum Diameter of Rivet.

The minimum diameter of rivets in riveted joints shall be five-eighths ($\frac{5}{8}$) of an inch after driving, and in no case less than the thickness of any one plate in joint.

31.—Rivet Heads.

The button head or partly spherical form of ordinary rivet heads is recommended, made to the sizes given in the following table:

Size	Button Heads		Countersunk	
Diameter of Rivet bef're Driving	Height	Diameter at base	Depth	Diamet. at outside of sheet
$\frac{5}{8}''$	15/32″	$1\frac{1}{8}''$	5/16″	1″
$\frac{3}{4}''$	9/16″	1 5/16″	$\frac{3}{8}''$	1 3/16″
$\frac{7}{8}''$	21/32″	$1\frac{1}{2}''$	7/16	$1\frac{3}{8}''$
1″	$\frac{3}{4}''$	$1\frac{3}{4}''$	$\frac{1}{2}''$	1 9/16″

Providing conical head rivets are used, the following proportions should be followed: The lap of the head at each side of shank should be about $\frac{1}{4}$ of an inch for a $\frac{3}{4}$ inch rivet, 5/16 of an inch for $\frac{7}{8}$ inch rivets, and $\frac{3}{8}$ of an inch for 1 inch rivets.

The height should not be less than three-quarters of the diameter of the rivet.

32.—Efficiency of Riveted Joints.

The efficiency that a unit of length of a riveted joint has to the same unit of length of the solid plate of which that joint is composed shall be calculated by the following formula:

In the following formula the strength of rivets in double shear is taken as being 1.75 times their strength in single shear:

$$C = \text{a constant} = \frac{\text{Shearing strength of rivets per sq. in.}}{\text{Tensile strength of plate per sq. in.}}$$

and may be taken as:

.85 for iron rivets and iron plates.
.70 for steel rivets and steel plates.
.65 for iron rivets and steel plates.

Chain riveted joints are prohibited for use under these regulations, which allow for use in boilers only the staggered types of riveting, and limit the number

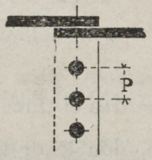
of rows of effective rivets in joints to three, whether in lap or butt strap construction.

K = Efficiency of joint.
Kt = Efficiency of plate in joint.
Ks = Efficiency of rivets in joint.
Kst = Efficiency of combined plate and rivets in joint.
K = Kt, Ks or Kst, whichever is least.
P = Pitch of rivets in outside row when calculating the efficiency of joints.
T = Thickness of plate in inches.
T1 = Thickness of each butt strap in inches.
d = Diameter of rivet holes in joint.

(a) Single Riveted Lap Joint.

$$Kt = \frac{P - d}{P}$$

$$Ks = \frac{a}{P \times T} \times C$$

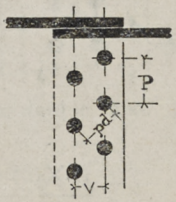


a = Area of one rivet in single shear.

(b) Double Riveted Lap Joint.

$$Kt = \frac{P - d}{P}$$

$$Ks = \frac{2a}{P \times T} \times C$$

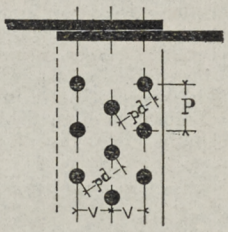


2a = Area of two rivets in single shear.

(c) Treble Riveted Lap Joint.

$$Kt = \frac{P - d}{P}$$

$$Ks = \frac{3a}{P \times T} \times C$$



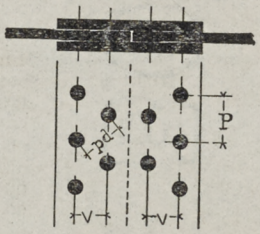
3a = Area of three rivets in single shear.

Single, double or treble riveted butt strap joints, with single butt straps, shall be considered equal respectively to single, double or treble riveted lap joints.

(d) Double Riveted Butt Joints with Equal Straps and Equal Pitch of Rivets in Each Row.

$$Kt = \frac{P-d}{P}$$

$$Ks = \frac{3.5a}{P \times T} \times C$$

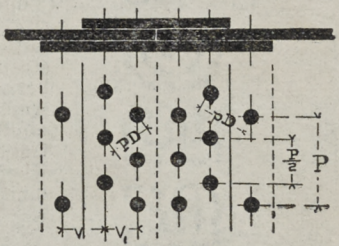


3.5a = Area of two rivets in double shear.

(e) Treble Riveted Butt Joints with Unequal Straps and Every Other Rivet Omitted in Outer Row.

$$Kt = \frac{P-d}{P}$$

$$Ks = \frac{8a}{P \times T} \times C$$



8a = Area of four rivets in double shear, plus one rivet in single shear.

$$Kst = \frac{(a \times C) + [(P-2d) \times T]}{P \times T}$$

a = Area of one rivet in outer row in single shear.

33.—Distance Between Rows of Rivets.

(*a*)

$$V = \frac{\sqrt{(11P+4d)(P+4d)}}{10}$$ = Minimum distance in inches between rows of rivets for lap joints and double riveted butt joints, with straps of equal width, when every other rivet is omitted in the outer row. And treble riveted butt joints, with straps of equal width, with full number of rivets in all rows.

(*b*)

$$V = \sqrt{\left(\frac{11}{20}P+d\right)\left(\frac{1}{20}P+d\right)}$$ = Minimum distance in inches between rows of rivets in double riveted butt joints, with equal straps, and with full number of rivets in all rows. And between outer and middle rows of rivets for treble riveted butt joints when every other rivet is omitted in the outer row.

(*c*)

$$V_1 = \frac{\sqrt{(11P+8d)(P+8d)}}{20}$$ = Minimum distance in inches for treble riveted butt joints between inner and middle rows when every other rivet is omitted in outer row.

(*d*)

$$PD = \frac{3P + 4d}{10}$$ = Minimum diagonal pitch in inches for treble riveted butt joints between inner and middle row when every other rivet is omitted in outer row.

(*e*)

$$pd = \frac{6p + 4d}{10}$$ = Minimum diagonal pitch in inches for all rows in double and treble riveted lap joints also for double and treble riveted butt joints, with full number of rivets in all rows.

(*f*)

$$pD = \frac{3}{10} P + d$$ = Minimum diagonal pitch in inches for outer and middle rows of treble riveted butt joints, when every other rivet is omitted in outer row.

34.—Butt Straps, with Full Number Rivets in all Rows

T_1 for double butt straps $= \frac{5 \times T}{8}$

T_1 for single butt straps $= \frac{9 \times T}{8}$

35.—Double Butt Straps, when every other Rivet is Omitted in Outer Row.

$$T_1 = \frac{5 \times T(P-d)}{8(P-2d)}$$

36.—Longitudinal Seams.

All longitudinal seams of horizontal cylindrical shells of boilers shall be above the centre line of boiler. No longitudinal seam of any boiler shall have a continuous length of more than ten (10) feet. The difference in location of adjoining longitudinal seams (where more than one) on the cross section of boiler, shall where practicable be not less than 30 degrees.

37.—Cylindrical Heads, Either Dished or Flat.

Convex heads, when dished to a radius equal to the diameter of the shell or drum to which they are attached or less, and when they are also true portions of spheres, do not require staying if their thickness is one-sixteenth of an inch more than the shell or drum plates as found by the formula, section 25.

The pressure allowable on heads which are dished to a radius greater than the diameter of shell to which they are attached is as follows: Being limited to that allowable for the shell to which they are attached and stayed as flat surfaces when thickness of head does not make "B" to equal that allowed for shell, but the resistance to rupture or collapse as found by the following formula may be considered when calculating the stays required:

$$B = \frac{(t-1) \times TS}{R \times 56}$$

B = Pressure allowable in pounds per square inch.
t = Thickness of plate in sixteenths of an inch.
TS = Tensile strength of plate, per square inch.
R = Radius to which head is bumped in inches.
h = Camber or height of bump measured from chord in inches.
c = diameter of spherical portion of head, exclusive of radius at flange in inches.

38.—Radius to Which Head is Bumped.

$$R = \frac{(\frac{1}{2}c)^2 + h^2}{2h.}$$

will give radius to which a head is bumped, care being taken to measure h and c correctly.

39.—Concave Heads.

Concave heads are to be considered as only sixty per cent. of the strength of convex after calculating as above. The circumferential joints for all such heads should be carefully calculated, being at least fifty-five per cent. the value of the solid plate, and double riveting used where practicable.

40.—Flat Heads.

Flat heads other than dome heads should be stayed preferably by longitudinal stays having substantial upset ends and fitted with nuts and washers, the area to be stayed being determined as follows: When the head is flanged and riveted to the shell, a portion of it becomes stiff enough to carry the boiler pressure without depending upon the braces. The distance that thus becomes self-supporting may be determined by the following formula:

The allowance in inches for shell as stay to head to equal

$$\frac{1}{2}\sqrt{\frac{112\times t^2}{B}}$$ or radius of curvature of head flange, whichever is greatest.

t = Thickness of head in sixteenths of an inch.
B = Working pressure.

41.—Area of Head to be Stayed.

When the area of any segment of a head to be stayed is required, the following formula shall be used:

$$A=\frac{4h^2}{3}\sqrt{\frac{2R}{h}-.608}$$

h = Height in inches of segment to be supported. (See sections 40 and 47a.)
A = Area of the segment in square inches.
R = Radius in inches of segment to be supported.

42.—Diagonal Stays.

Diagonal (round or square) stays must be increased in area to an amount which shall be not less than the area that would be required for a direct stay, multiplied by $\frac{H}{L}$

When H equals the length of diagonal stays, L equals the length of a line drawn at right angles from the surface to be supported to a point on this line at right angles to the end of the diagonal stay.

The angle which a diagonal stay makes with the shell shall not exceed thirty degrees (30°), and should be as much less as possible. The welding of crow feet or palm ends to stays is prohibited.

43.—Rivet Area for Stays.

The rivet area attaching stays of all kinds to a head or shell shall aggregate twenty per cent. (20%) greater than the stay area. If, however, the ends are attached to angle or tee bars, the bolt or pin being in double shear, may have an area of 25 per cent. less than the stay, but no allowance is to be made for the value of the bars as stays in this or any other case.

44.—Minimum Diameter of Rivets in Stays.

The minimum diameter of rivets attaching stays of all kinds shall be three-quarters ($\frac{3}{4}$) of an inch.

45.—Gusset Stays.

When gusset stays, which must be attached to plates between two angle irons, are used, their area shall be ten per cent. (10%) in excess of that required for diagonal stays, but as diagonal stays can be used in most cases where gusset stays can they should be given the preference.

The working pressure allowed on gusset stays shall be calculated as follows:

$$B = \frac{Swt \times W \times T}{E} \times \frac{L}{H} \times .9$$

Where—

E = Area in square inches of surface supported.
Swt = Working tensile strength in pounds per sq. in.
W = Width of web of stay at narrowest part.
T = Thickness of web in inches.
H = As for diagonal stays.
L = As for diagonal stays.

46.—Flat Surfaces.

The maximum stress allowable on flat plates supported by stays shall be determined by the following formula:

All stayed surfaces formed to a curve, the radius of which is over 21 inches, excepting surfaces otherwise provided for, shall be deemed flat surfaces.

$$\text{Working pressure} = \frac{C \times t^2}{p^2}$$

where—

t=Thickness of plates in sixteenths of an inch. Where doubling plates are used for "t" take 75% of the combined thickness of both plates.

p=Pitch of stays in inches when equally spaced in both directions.

C=112 for screw stays with riveted heads, plates seven-sixteenths of an inch thick and under.

C=120 for screw stays with riveted heads, plates over seven-sixteenths of an inch thick.

C=120 for screw stays with nut outside sheet, plates seven-sixteenths of an inch thick and under.

C=125 for screw stays with nut outside sheet, plates over seven-sixteenths of an inch thick and under nine-sixteenths of an inch.

C=135 for screw stays with nut outside sheet, plates nine-sixteenths of an inch thick and over.

C=175 for stays with double nuts having one nut on the inside and one nut on the outside of plate, without washers or doubling plates.

C=160 for stays fitted with washers or doubling strips which have a thickness of at least the thickness of the plate, and a diameter of at least .5 of the greatest pitch of the stay, riveted to the outside of the plates, and stays having one nut inside of the plate, and one nut outside of the washer or doubling strip. For t take

75 per cent. of the combined thickness of the plate and washer or plate and doubling strip.

C=200 for stays fitted with doubling strips which have a thickness equal to at least the thickness of the plates reinforced, and covering the full area braced (up to the curvature of the flange, if any), riveted to the plate, and stays having one nut outside and one inside of the plates. Doubling plates to be substantially riveted. For t take 75 per cent. of the combined thickness of the two plates.

C=200 for stays with plates stiffened with tees or angle bars having a thickness of at least the thickness of plate and depth of webs at least one-fourth of the greatest pitch of these stays, and substantially riveted to the plates, and stays having one nut inside bearing on washers fitted to the edges of the webs, that are at right angles to the plate. For t, take 75 per cent. of the combined thickness of web and plate. (When the pitches of stays are unequal,

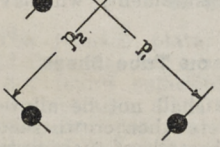
$\frac{l^2+w^2}{2}$ is to be taken instead of p^2)

l=The pitch of stays in inches in one row.

w=Distance in inches between two rows of stays.

46a.—Irregular Staying.

In case of irregular staying, as in figure—



$\frac{(p_1+p_2)^2}{8}$ is to be taken instead of p^2

47.—Tube Sheets.

The minimum thickness for a tube sheet of any size shall be five-sixteenths (5/16) of an inch.

47a.—Support Given by the Tubes.

The rectangular area covered by the tubes in tube sheets shall, in accordance with the following formula, be considered as stayed by the tubes, but no value is to be allowed for beading as staying, its use being only to protect ends of tubes from fire or rust.

$$\frac{1}{2}\sqrt{\frac{112\times t^2}{B}} - \frac{dr}{2}$$

= Distance in inches from edge of tube hole to outside edge of rectangular area stayed by the tubes.

t = Thickness in sixteenths of an inch.
dr = Diameter of tube holes.
B = Working pressure.

47b.—Minimum Size of Ligament.

The minimum size of ligament between any two tubes shall be three-tenths(.3) square inches in section or not less than three-fourths of a lineal inch measurement, whichever is greatest for boilers with horizontal tubes. For vertical boilers the minimum size shall be three-tenths (.3) square inches in section, or one-half ($\frac{1}{2}$) of a lineal inch measurement, whichever is greatest.

47c.—Compressive Stress on Tube Sheet.

A greater compressive stress shall not be allowed on the upper edges of tube sheets when crown sheets are supported by girders, and the ends of such girders

rest on the upper edges of tube sheets, the girders not being supported by sling stays, than is found by the following formula, which limits such compressive stress to 9,000 pounds per square inch of sheet between tubes:

$$B = \frac{(D - dr_1)T \times 18000}{D \times W}$$

D = Least horizontal distance between centres of tubes in ins.

dr_1 = Inside diameter of tubes in inches.

T = Thickness of tube plate in inches.

W = Distance in inches between tube sheet and opposite side of combustion or fire box.

The area of the tube sheet between the upper side of tubes and the bearing point of girder must be sufficient to transmit without distortion of the tube plate the stress above dealt with.

48.—Belly Stays.

In boilers thirty-six inches and upwards in diameter of the locomotive type with straight firebox tube sheets, the portion between bottom tubes and top staybolts in throat sheet must be stayed as for flat surfaces by belly stays riveted to the barrel, their ends arranged to receive staybolt from tube sheet.

49.—Internally Fired Furnaces or Parts of Boilers (other than Ordinary Fire Tubes) Subjected to Compression.

The furnace plates in plain circular internally fired furnaces, not exceeding 42 inches in diameter, if not found sufficiently strong, must be stayed as flat surfaces, allowing in the calculations for such seventy-five per cent. (75%) of the value of the resistance to collapse, as found by the following

formula, the pitch of the stays being computed by the rule for flat surfaces, but the pitch shall in no case exceed eight inches on the furnace plate. For furnaces over forty-two inches in diameter, no allowance for value of resistance to collapse shall be made. Care must be taken not to reduce the efficiency of the riveted joint when applying these stays.

$$B = \frac{C \times T^2}{(L_1 + 1)Dr}$$

Where—

Dr = Outside diameter of furnace in inches.

T = Thickness of plate in inches.

L_1 = Length of furnace in feet, or length between rings.

C = Constant according to the following circumstances:

B = Working pressure per square inch, which must not exceed that found by the limiting formula, as follows:

$$B = \frac{10000 \times T}{Dr}$$

Furnaces with butt joints and rivet holes punched small and reamed out in place.

112500 where the longitudinal seams are double riveted, and fitted with single butt straps.

100000 where the longitudinal seam is single riveted, and fitted with single butt strap.

112500 where the longitudinal seam is single riveted, and fitted with double butt straps, or where seam is welded.

Furnaces with lap joints and rivet holes punched small and reamed out in place.

96000 where the longitudinal seams are double riveted.

87500 where the longitudinal seams are single riveted.

49a.—Adamson Type Furnaces.

For furnaces of Adamson type which do not require staying:

$$B = \frac{9900 \times T}{3 \times Dr} \times \left(5 - \frac{l_1 + 12}{60 \times T}\right)$$

T = Thickness of plate in inches.
Dr = Outside diameter of body of furnace in inches.
l_1 = Length in inches between flanges.

49b.—Corrugated Steel Furnaces.

$$B = \frac{14000 \times T}{Dr}$$

Where—
T = Thickness in inches.
Dr = Outside diameter in inches, measured at the bottom of the corrugations.

50.—Truncated Cones.

Flues used in vertical boilers as upper combustion chambers formed in the shape of a frustrum of a cone when new and made to true circles, shall be allowed steam pressure according to the following formula:

$$B = \frac{965.625t - 53.045l_1}{Dr}$$

B = Working pressure in pounds per square inch.
t = Thickness of cone in sixteenths of an inch, not to be less than five-sixteenths of an inch.
Dr = Outside mean diameter in inches.
l_1 = Length of cone in inches, which must not exceed (135 × thickness of cone plate in inches) − 12.

When the mean diameter of frustrum of cone exceeds 36 inches, the cone shall be deemed a flat surface, and must be stayed accordingly.

51.—Crown Sheets in Loco Type or Other Boilers.

When the tops of fire boxes or of combustion boxes are flat (excepting the outside sheet is parallel to the same) they may be supported by girders properly fitted to the edges of the tube plate, and the back plate or to the side plates, as the case may be, by chipping and filing, so that a good bearing may be effected on the edges of these sheets, and also upon the flanged curve of the crown sheet. When the tops of fire-boxes or combustion boxes are curved, they may be stayed by radial or direct stays, which do not enter the sheets at more than five degrees (5°) from a right angle to a tangent on sheet at point of contact, the pitch and strength of stays being determined by formula. The several rows of longitudinal stays on crown sheets must make equal angles from vertical centre line with the corresponding rows on opposite side, and their pitch shall be determined by the formula for flat surfaces. No stays shall be permitted to pass between the tubes.

51a.—Flat Crown Sheets on Traction and Portable Boilers.

Flat crown sheets shall not be allowed in traction and portable engine boilers, and the camber of same as measured from the extension of side sheet to meet the curvature of centre of crown sheet shall not be less than the width of firebox $\times 0.14$.

52.—Girder Stays on Crown Sheets.

The working pressure on girder stays supporting the top of fireboxes or combustion boxes shall be calculated by the following formula, the pitches of girder stays and bolts in same being determined by formula for staying flat surfaces:

$$B = \frac{C \times g^2 \times T}{(W - p)D \times L_1}$$

W = Width in inches of combustion or firebox in line with girder.
p = Pitch of supporting bolts in inches.
D = Distance in inches between girders from centre to centre.
L_1 = Length of girder in feet.
g = Depth of girder in inches at centre.
N = Number of supporting bolts.
T = Thickness of girder in inches.

$$C = \frac{1200N}{(N+1)} \text{ when the number of bolts is odd.}$$

$$C = \frac{1200(N+1)}{N+2} \text{ when the number of bolts is even.}$$

If the girders are made of steel, the value of C is to be increased 10 per cent.

53.—Water Spaces.

The water space outside the furnace of any internally fired boiler shall not be less than two inches in the clear.

When the tops of fireboxes are supported by girders, there shall be a clear waterway between the girders and crown sheet of not less than $1\frac{1}{2}$ inches and preferably $1\frac{3}{4}$ inches.

54.—Wagon Tops.

Wagon tops or saddle sheets of boilers are preferably made of one sheet with side sheets of water legs. When radial stays from crown sheets enter the wagon top at any point at an angle less than sixty-five degrees (65°) from a tangent to the wagon top at point of contact, the camber of crown sheet shall be increased to bring the angle within this limit, and insure full threads of stay in wagon top.

55.—Back Heads of Loco Type Boilers.

The portion of back head in a loco type boiler not stayed to firebox will be stayed under the formula for flat surfaces.

56.—Throat Sheets.

Throat sheets in loco type boilers must not be thinner at any point than the sheets they are attached to at the barrel connection. The barrel connection to firebox casing must be double riveted.

57.—Hydrostatic Tests.

When hydrostatic tests are applied to boilers built according to these regulations, they will be applied in the ratio of one hundred and fifty per cent. of the working pressure.

58.—Tensile Strength.

When the actual tensile strength of steel or wrought iron shell plates is not known, it shall be taken as 55,000 pounds for steel, and 45,000 pounds for wrought iron, provided sample of material cut from the boiler will pass prescribed bending test.

59.—When Special Formula is Necessary.

If it occurs that there are parts of any type of boiler for which formula has not been provided in these regulations, the case shall be submitted to the Department.

IV.—MATERIAL.

60.—Plate Maker's Name and Tensile Strength.

Every steel plate intended for the construction of boilers hereafter built for operation under these Rules must be stamped by the makers with their names and the tensile strength. The stamps must be so located that they are plainly visible after boiler is constructed.

61.—Steel Plates.

Steel plates are to be homogeneous, made by the open hearth process and having the following qualities:

61a.—Qualities of Plate and Limits of Same.

Shell plates, or plates on which flanging is to be done, may have from 55,000 minimum to 65,000 maximum pounds per square inch tensile strength, elastic limit not less than one-half the tensile strength, elongation not less than twenty-two per cent. in eight inches, cold and quench bends 180 degrees flat on itself without fracture on outside of bent portion. Maximum phosphorus .04 per cent., maximum sulphur .04 per cent.

61b.—Firebox Steel.

Firebox plates to have from 52,000 minimum to 62,000 maximum pounds per square inch tensile strength, elastic limit not less than one-half the ultimate strength, elongation not less than 26 per cent. in eight inches, cold and quench bends 180 degrees flat on itself without fracture on outside of bent portion. Maximum phosphorus .035 per cent., maximum sulphur .035 per cent.

61c.—Rivet Steel.

Steel for boiler rivets to have from 45,000 to 55,000 pounds per square inch tensile strength, elastic limit not less than one-half the tensile strength, elongation not less than 28 per cent. in eight inches, cold and quench bends 180 degrees flat on itself without fracture on outside of bent portion. Maximum phosphorous .04 per cent., maximum sulphur .04 per cent. It must test hot and cold by driving down on an anvil, the rivet being held in a tool. The head must flatten until its diameter is two and a half times the diameter of the shank (hot test), and one and a half times the diameter of the shank for cold test, all without developing cracks or flaws.

62.—Wrought Iron Plates and Bars.

Wrought iron, where used, must stand the same bending tests as steel when bent lengthwise of plates or bars, but the tensile strength will be 20 per cent. less, also the elongation.

The elastic limit will be one-half the tensile strength.

63.—Braces, Stays and Stay Bolts.

All braces, stays and stay bolts are to be made of iron or mild steel specially manufactured for the purpose. Iron shall have a tensile strength not less than 46,000 pounds per square inch, elastic limit not less than 26,000 pounds, elongation not less than 22 per cent., in a length of eight inches. Steel to have a tensile strength of 62,000 pounds maximum, and not less than 52,000 pounds, elastic limit not more than 33,000 pounds, or less than 26,000 pounds per sq. inch, elongation not less than 25 per cent. in eight inches.

63a.—Tests for Stay Bolts.

Material for stay bolts must be smoothly rolled and free from slivers, depressions, seams, crop ends and evidences of being burnt.

Iron for stay bolts must stand the following tests: Double bending test. Close in both directions without flaw.

Nick and break test. A bar nicked all around to a depth not less than 8% and not more than 16% of the diameter of the bar, and broken, shall show a clean fibre entirely free from crystallization.

Steel for stay bolts must stand the following bending test: A bar taken at random full threaded must bend cold 180° around a bar of its own diameter without showing any cracks or flaws. The use of the Whitworth type of thread is recommended for stay bolts.

64.—Tubes.

Tubes of whatever material manufactured must be truly cylindrical in form and meet the following physical tests:

For iron and steel the percentage of elongation must be not less than 22% in eight inches, and the tensile strength, elastic limit, etc., must agree with that given for rivet bars.

Any tube must, when cold, stand without cracking, expanding on a mandril by repeated blows with a hand hammer, until it is one-eighth larger than its original diameter.

A piece cut from the tube must flatten closely without cracking, and a piece cut lengthwise from a tube and flattened must stand bending back on itself both cold and after being heated to a red heat and quenched, without cracking.

65.—Malleable Iron Castings.

Malleable iron castings, where used, must be clean and free from cracks. Samples from material intended for use in boilers constructed under these regulations must stand repeated blows from a hammer when cold without fracture.

66.—Rejection of Material.

In cases where tests show that for stay bars, rivet bars, tubes or malleable iron castings three pieces (or in cases of lots of a hundred or more, three (3) per cent. of those) subjected to the test, fail to meet the foregoing requirements, the whole lot so submitted may be rejected.

67.—Cast Iron.

It is desirable that the use of cast iron in boiler construction under the provisions of these regulations be discontinued.

It may be used for manhole plates, handhole plates and nozzles, for pressures not exceeding one hundred pounds, but its use for manhole rings, steam domes, or like purposes, is prohibited.

It must be clean and of a soft grey texture.

Cast iron flanges and fittings shall not be used on any steam main or connection used to carry superheated steam.

68.—Steel Castings.

Steel castings may be made by the open hearth or basic process, but must receive such heat treatment as will produce a fine grained, homogeneous and tough metal, free from slag, cracks and cavities, injurious blowholes and surface or other defects.

Tensile strength per square inch not below 60,000 pounds.

Elongation in 2 inches not below 23 per cent.

Reduction in area not below 30 per cent.

Phosphorous not over .06 per cent.

Sulphur not over .06 per cent.

V.—WORKMANSHIP.

69.—Good Workmanship Essential.

The manner in which punching, swaging, cutting and caulking or beading tools, whether hand or machine used, are maintained, also the character of workmanship generally, will be taken into consideration when determining the factor of safety. No leaks will be permitted to continue.

70.—Plates Not to be Damaged During Construction.

The edges of all plates must be neatly planed, sheared, rolled, bent or chipped, without damaging them in any way.

71.—Caulking.

Caulking is to be done by hand or pneumatic hammers, and round-nosed tools; caulking edges are to be carefully prepared, the edges being bevelled sufficiently to hold the caulking. The fit of the joint must be made in the laying of the plates, and excessive caulking avoided, and the lower plate not nicked or damaged by caulking tools.

72.—Butt Straps.

Butt straps must be pressed to correct shape and edges of sheets forming joints bent after marking (but before holes are made), to insure good fitting when assembled and correctness of form. The edges of butt straps must be planed, and the joint at connection be protected. The scarfing of butt straps must take in the circumferential rivets.

73.—Holes in Sheets.

The drilling of rivet holes and stay bolt holes from solid after plates are fitted is preferred, but they may, if not less in diameter than the thickness of the

plate, be punched small before rolling, after the edges of plates are bent, and drilled in line after assembling. If holes are punched, they must, up to thirteen-sixteenths (13/16) of an inch in diameter, be punched one-eighth ($\frac{1}{8}$) of an inch less, and for rivet holes over thirteen-sixteenths (13/16) of an inch in diameter, be punched three-sixteenths (3/16) of an inch less, and reamed after assembling to insure exact size and good fair holes (all material damaged by punching being entirely removed), and all burrs must be removed, the plates being separated for this purpose.

73a—Holes to be Fair.

After reaming, all holes for rivet seams must be fair, punch marks obliterated by it, and so formed that rivet heads will lie fairly to the sheet and be concentric with the rivets.

Holes for stays and stay bolts must be left small for reaming to insure the threads in both sheets being full and in straight line.

74.—Scarfing.

All plates requiring scarfing must be properly prepared, in order to allow the joint to be well fitted and set up.

The lap over rivets on edge of scarfed portion must be at least equal to the diameter of the rivet.

Joints must be examined while assembling and before any riveting is done. When assembled, the joints must be close and well fitting, being brought together by fitting up bolts in holes specially prepared. The bringing of plates together by rivets is forbidden. Holes in flanged plates must not be punched or drilled on inner plates until plates are assembled, when holes may be marked off from outer plates, the holes then made and reamed after again assembling.

75.—Drift Pins.

Drift pins may be used with light hammers to pull the plates into position, but they must not be driven with such force as to disturb the metal about the hole.

76.—Templets.

The use of permanent steel templets for standard work is recommended. For other work it is considered good practice to prepare one set of plates from which while flat a second set is marked off and assembled, the first set, if correct, being used as templets for the rest.

77.—Rivets.

Rivets should be driven wherever possible by power riveters. Air hammers may be used where practicable. Rivets must be heated their whole length, and be of such length as to fill the hole by upsetting and form full heads, being left to cool under pressure of riveter until black.

78.—Flanging Sheets.

Flanging or forming should be done at one heat. Where two or more heats occur the whole plate should be heated at the conclusion of the flanging, and left to cool slowly and equally, being covered and unexposed to draughts of cold air, the same treatment being given plates flanged in one heat, in which case reheating is not necessary. Sharp corners in flanges must not occur. The minimum inside radius allowed in flanges is one inch.

79.—Tubes—Fitting and Expanding.

Tubes must fit the holes in tube sheets as nearly as possible before expanding, the end nearest fire being a driving fit when applied. The ends must

be prepared for this, and the holes in sheets be truly round, with edges slightly rounded and true to size.

The hole in sheet where tube is entered is to be only large enough to allow free entry of tube.

Tubes must be expanded by roller expanders.

The ends of tubes must not extend more than three-sixteenths to one-quarter inch beyond sheet, according to thickness of tube, and then be beaded against tube sheet without cracking, to insure which the ends of tubes must be annealed. The hand welding of tubes is prohibited.

80.—Tube Sheets.

All tube holes must be truly round. The holes may be punched three-sixteenths of their diameter small, and bored to size with a rose cutter. The edges of holes are to be slightly rounded to prevent damage to tubes.

VI.—FITTINGS.

81.—Quality and Strength.

The material of all mountings and fittings must be of good quality, and sufficient strength to withstand strains from internal pressure and work for their respective uses. Those attached to boilers carrying over one hundred and twenty-five pounds of steam shall be of the class known as extra heavy.

The nipples attaching same, when over one inch in nominal diameter and screwed connections are permitted, they must be made at least fifty per cent. (50%) thicker than ordinary standard steam pipe.

In applying fittings or their bases when riveted to boiler they must be carefully fitted to boiler before riveting, and in case of cast iron a caulking strip of soft steel or iron inserted between the boiler plate

and cast iron. The thickness of the flange of any iron casting riveted to a boiler must not be less than three times the thickness of the sheet to which it is riveted.

They must be provided for every boiler as follows:

82.—Safety Valves.

Every boiler, including heating boilers not subject to inspection by the Act, shall be provided with a lock pop side discharge safety valve of approved design under the following conditions:

The springs and valves are to be cased in, so that they cannot be easily tampered with.

Provision is to be made to prevent the valves flying off in case of springs breaking.

Lifting gear is to be provided to ease all valves.

The springs must have a sufficient number of coils to allow a compression under the working load of one-eighth the diameter of the valve.

The valves are to be provided with a cap for safely protecting its adjustable parts, and fitted in such a manner that it can be efficiently sealed by the Inspector.

With valves over two inches in diameter, flanged connections must be used.

82a.—Area of Valve.

The area of such safety valve measured at the inside point of contact between the valve and the seat shall be proportioned to the size of the fire grate according to the following formula:

$$A = \frac{37.5 \times G}{B + 15}$$

Where A= area of valve in square inches at point of contact between valve and seat, G=area of fire grate in square feet, B=working pressure in pounds per square inch.

Note: This formula will not apply to safety valves for heating boilers carrying less than 20lbs per square inch.

82b.—Testing Safety Valves.

When considered necessary, the safety valves shall be tested under full steam, and full fires for at least fifteen minutes, with feed water shut off and stop valve closed; if the accumulation of pressure exceeds ten per cent. of the working pressure of the boiler, a larger safety valve must be substituted.

82c.—Twin Valves.

All boilers requiring safety valves to be over three (3) inches in diameter are to be equipped with twin valves instead of one large valve. Where the twin valves, or more than one valve, is used, the minimum combined cross sectional area shall be in accordance with formula (Clause a).

82d.—No Cast Iron Seat Allowed.

Safety valves having either the seat or disc of cast iron shall not be allowed.

82e.—Maximum and Minimum Diameter of Valves.

The diameter of a safety valve used on a boiler shall not be less than one (1) inch or more than three (3) inches.

82f.—Location of Valve, Escape Pipe, Etc.

All safety valves are to be fitted independently of any other connection to the boiler, and must be placed immediately at the boiler, and no valve of any description shall be placed between the safety valve and the boiler, nor on the escape pipe between the safety valve and the atmosphere. The escape pipe shall have an open-ended drain at its lowest point. The safety valve shall be located so as to be accessible, and must not be connected to an internal pipe in the boiler.

83.—Fusible Plug.

Every boiler shall be equipped with at least one (1) fusible plug, which shall be kept in clean and efficient condition. The body of the plug shall be composed of brass, with a taper hole through its centre, the smallest diameter of this hole to be at least three-eighths ($\frac{3}{8}$) of an inch, and filled with good banca tin, to efficiently protect the fire line, when the water falls below the minimum level prescribed by these regulations. This plug shall project through the sheet not less than three-quarters ($\frac{3}{4}$) of an inch, and be located as shown and approved in design. All fusible plugs must be renewed at least once each year and examined at each washout.

84.—Steam Gauge.

Every boiler shall be provided with a correct pressure gauge of proved reliable make, which shall be tested by the inspector at the time of inspection, and must be set to correspond with a standard test gauge, and placed so as to be plainly visible to the operator. Traction and portable boilers shall be provided with steam gauge of the double tube type.

84a.—Steam Gauge Dial.

The dial of the steam gauge shall be graduated to not less than one and one-half times the maximum pressure carried on the boiler, and for dark hours shall be well lighted.

84b.—Syphon and Cut-out Cock.

All steam gauges shall be connected directly to the boiler, and shall be fitted with a syphon or equivalent device sufficiently large, to fill the gauge tube with water, a cut-out cock with lever handle, to be placed between the syphon and the boiler; to

which it is to be directly coupled and not connected with any other fitting.

84c.—Inspector's Test Gauge Connection.

A one-quarter (¼) inch size pipe connection must be provided on every boiler to permit inspector's gauge to be connected above the cock or syphon pipe for the purpose of testing in service the working steam gauge on boiler.

85.—Gauge Glass.

Every boiler shall have at least one water glass not less than six (6) inches in length (as measured between the gland nuts), the visible bottom end of which shall be at least two (2) inches above the fire-line (See Sec. 102).

All water gauges must be capable of being operated from floor of boiler room or working platform of a traction engine or portable boiler, and in dark hours to be well lighted.

86.—Gauge Cocks.

Every boiler shall have two (2), and in boilers exceeding thirty inches in diameter three (3) gauge cocks with three-quarter (¾) inch pipe thread connections to boiler and minimum bore of three-eighths (⅜) of an inch, located within the range of the gauge glass, the lower cock to be placed in the same plane as the bottom of the glass, and the others at least two (2) inches apart, measured vertically. In traction or portable boilers the gauge cocks must be inserted within reach of operator in the face plate or in a water column attached to the same. The cocks must be so made that the passages can be cleaned out without removing cock from boiler. In stationary boilers where gauge cocks cannot be conveniently

operated, a second gauge glass may be used instead of gauge cocks, provided the second gauge glass is separately connected to the boiler.

87.—Water Column and Connections.

The internal diameter of any water column and pipes attaching the same to the boiler shall be as follows:

Diameter of Boiler	Least internal Diameter of Pipe	Least internal Diameter of Column
Up to and including 36 ins	1 inch	2 inches
Above 36 ins. to 54 ins..	1¼ inches	3 inches
Above 54 inches.....	1½ inches	3 inches

Straightway stop valves or cocks of correct size are to be fitted top and bottom of the column. The fittings at the connections to boiler shall be as short as possible, and conveniently arranged with tees or crosses having brass plugs for cleaning out. The waste pipe and valve at the bottom of the column shall be at least one-half the diameter of connecting pipes from boiler to column, and the end of the waste pipe plainly visible so that the discharge may be noted.

88.—Feed Water Supply.

Each boiler of fifteen (15) horse power in capacity or over shall be equipped with two (2) separate means capable of supplying feed water, while the maximum steam pressure is carried on the boiler. Direct pressure to the boiler from a waterworks shall not be considered as one of the two means. A sufficient reserve supply of water for feeding boiler must in all cases be provided for use with injectors or pumps.

88a.—Feed Arrangements.

Each boiler shall have a feed pipe fitted with a check valve and also a stop valve between the check valve and the boiler. The feed water should be fed at the coolest part through an internal pipe where possible, but never near the parts of the boilers that are exposed to the direct heat of the fire, or through the blow-off connection. Mud pans at water level at end of internal feed pipe are recommended, but they must not rest on the tubes.

89.—Stop Valves on Steam Mains.

Each steam outlet for a boiler (except safety valve connections) must be fitted with a stop valve immediately at the boiler, in addition to the stop valve at engine. Where the working pressure on steam mains exceeds eighty (80) pounds per square inch, any stop valve three (3) inches in diameter or over shall be of the outside screw and yoke gate type.

The use of angle valves at the end of a long steam main is not permissible.

90.—Steam Mains.

Provision shall be made for the expansion and contraction of steam mains connected to all boilers, with substantial anchorage at suitable points, to prevent perceptible vibration, on the boiler shell plates.

91.—Drains.

All steam mains shall be efficiently drained. Where traps are connected to high pressure drains, the discharge end of trap shall be open for observation at all times. All drain cocks and valves must be accessible, and so placed as to render it practicab e to drain any portion of the steam pipe or chests n connection therewith.

92.—Blow-off Pipes and Valves.

Each boiler must be provided with a substantial blow-off pipe and straightway valve. The minimum diameter shall be one (1) inch, and the maximum two and one-half (2½) inches. The pipe and valve must be adequately protected from the products of combustion. Globe or angle valves shall not be used for this purpose. Each blow-off pipe in a battery of boilers shall be connected independently to the drain, or open to the atmosphere.

The valve is to be connected to the boiler at the lowest point; if above one inch in diameter, a reinforcing plate is to be riveted to outside of shell of boiler, and the blow-off pipe or valve attached to it. For externally fired boilers, such as return flue and return tubular, the blow-off connection must be made to the bottom of the shell, and to the mud drum or header for water tube boilers at the back end.

An opening in brick work for the blow-off pipe shall be fitted with an ample cast or wrought-iron sleeve, to provide for free expansion or contraction. A bottom blow-off cock shall be protected by a guard or gland. The end of a plug shall be distinctly marked in line with its passage.

93.—Side Lugs and Settings for H.C. Boilers.

The following rules shall be observed in the setting of cylindrical externally fired boilers:

(*a*) No boiler shall be suspended from the crown or allowed to stand on a pedestal at the back end.

(*b*) All externally fired boilers up to and including twelve (12) feet in length may be supported upon four (4) cast iron brackets, resting upon substantial plates set in the brickwork, and the back lugs resting upon rollers between the lugs and plate to provide for expansion of boiler.

(*c*) Boilers over twelve (12) feet and under sixteen (16) feet long shall be suspended at the back end

from single side lugs placed on each side. The front end shall be supported by steel brackets resting upon a substantial plate let into the brickwork. All such plates must be carefully levelled to fit the brackets.

(*d*) Boilers sixteen (16) feet long and over shall be suspended front and back by side lugs set in pairs. All lugs and brackets shall be located at each side above the fire-line, and properly fitted to the curvature of the shell. The shearing stress on rivets attaching same must not exceed eight per cent. (8%) of the shearing strength.

(*e*) All lugs must be of steel plate, and when set in pairs so designed and located as to allow an equal stress upon each lug.

(*f*) Suspension, where required by the preceding clauses, shall be from wrought iron or steel beams, which shall be carried by and secured to iron or steel columns (preferably cast iron), having bases bolted to substantial foundations. (See Figs. 1 and 2.) Suspension beams or supporting columns shall not rest on the side walls of the brickwork setting.

The maximum fibre stress for suspension beams and columns must in no case exceed 12,500 pounds per sq. in.

94.—Back Arch.

Back arches shall be set in such a manner as to allow for the free expansion of the boiler, and placed clear of the fusible plug.

All flues and back settings shall be constructed with doors in lower part of setting, not less than sixteen (16) inches by sixteen (16) inches so arranged as to be easily accessible at all times.

Distances from back head of return tubular boilers to the back wall should not be less than the following:

20 inches for boilers 30 inches to 42 inches in diameter.

24 inches for boilers 44 inches to 60 inches in diameter.

28 inches for boilers 60 inches to 72 inches in diameter.

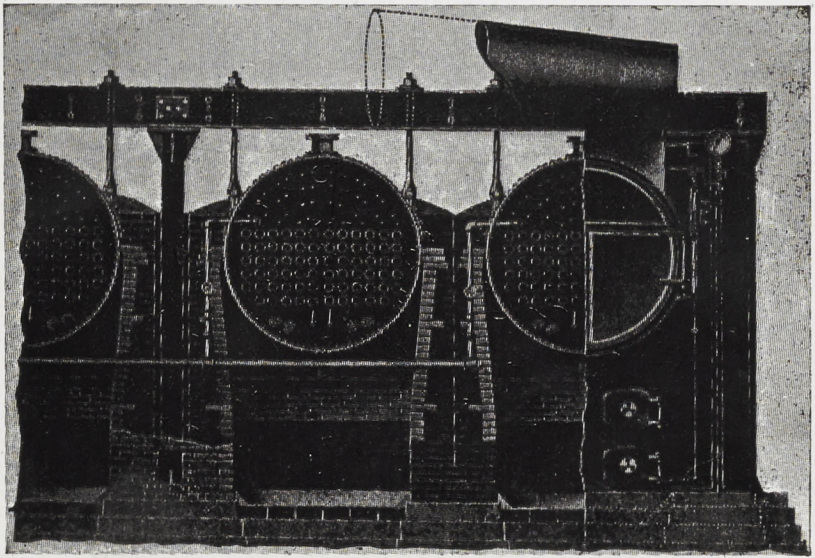


Fig 1.—Front Elevation and Partial Section of Suspended Boilers.

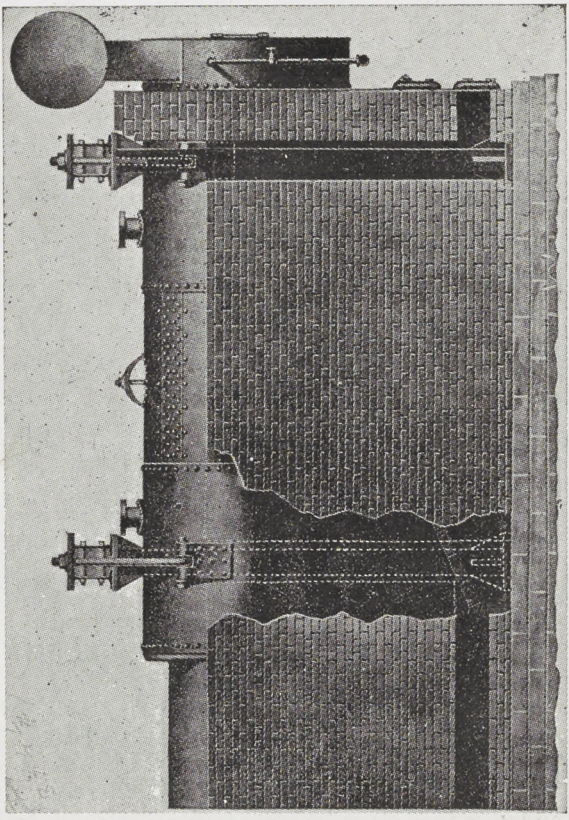


Fig. 2.—Side View of Suspended Boiler.

95.—Boiler Room Doors.

It is recommended that all exits from boiler rooms should open outwards.

VII.—INSPECTION.

96.—Precaution to be Taken When Entering Boiler.

When any person enters a steam boiler which it is possible to connect with another boiler containing steam, a man must be placed at his disposal to prevent the danger of steam being turned into the boiler which he enters during the time he is inside it.

97.—Lowest Rating of One Boiler in a Battery to be Taken.

When more than one boiler is connected to a main steam pipe, and for any reason the working pressure of one of them is reduced, the safety valves on the other boilers so connected shall be set to correspond with the safety valve on the boiler carrying the lowest working pressure.

98.—Inspectors May Drill Holes Where Necessary.

When the inspector has doubts of a boiler being defective he may drill or cause to be drilled the part he has doubt of to ascertain the thickness and condition of same.

99.—Boiler to be Prepared for Inspection and Tests.

Before a stationary boiler is subjected to a hydrostatic test, the owner or operator shall see that it is opened for inspection, the manhole and handhole plates removed, the flues cleaned, and all soot

and ashes removed from inside and outside of setting, and in case of a portable boiler the owner or operator shall see that the furnace grates and straw burners are taken out and the firebox and smoke box thoroughly cleaned.

100.—Inspector to Have Free Access to Boiler.

The owner or operator shall allow an inspector free access to the same, and shall furnish water and fill the boiler to permit of the hydrostatic test being made, and when necessary shall remove any jacket or covering from the boiler as directed by the inspector. He shall provide the necessary labor to assist the inspector in making his inspection, and shall point out any defect that he may know of or believe to exist in the boiler or machinery connected therewith.

101.—Inspector May Close Down a Boiler in a Dangerous Condition.

If a defect is discovered in a boiler which is under steam pressure, and if, in the opinion of the inspector, such defect may cause immediate danger, he shall order the engineer or person in charge to draw the fire and blow off the steam, and the engineer or other person in charge shall obey such instructions without reference to anyone else.

102.—Fireline to be Protected.

Inspectors shall satisfy themselves that the friction (fire-line) of the heating surface is at least two (2) inches below the prescribed minimum water line of the boiler in all horizontal and locomotive firebox boilers. In upright tubular boilers of the submerged tube type, the minimum water line shall be at least two (2) inches above the upper tube plate, and in dry-top upright tubular boilers the minimum water

line shall be not less than two-thirds ($\frac{2}{3}$) the distance between the tube sheets (measured from the lower tube sheet). Inspectors shall also satisfy themselves that flues and tubes are round and true, also that the openings for the passage of water and steam respectively and all pipes and tubes exposed to the heat are of proper dimensions and free from obstruction.

103.—Handrail to Flywheel, Etc.

Inspectors shall also see that all fly wheels, pulleys, and belting in the engine and boiler rooms are properly protected, and that the keys in pulleys do not project beyond the end of shafting, and see that set screws on collars are countersunk when considered necessary.

104.—Flywheel Velocity.

The maximum velocity that will be allowed on the periphery of any cast iron fly wheel shall not exceed 6,000 feet per minute. Automatic stops shall be provided to each engine having a fly wheel 8 feet in diameter and over.

105.—Nominal Horse Power.

The nominal horse power of boilers, or of steam plants, for the rating of fees and engineers' certificates, is to be calculated as follows:

For all stationary boilers excepting loco firebox—

$$\frac{HS}{12} = \text{Nominal horse power.}$$

For locomotive firebox, traction and portable—

$$\frac{HS}{9} = \text{Nominal horse power.}$$

HS = Heating surface.

106.—Inspection of Steam Mains.

All steam pipes and connections are to be carefully examined by the inspectors at each inspection. Inspectors may subject all main steam pipes to a hydrostatic test of twice the working pressure of the boilers to which they are connected, at least once every four years, or as often during this period as in their judgment they may deem it necessary; provided, however, that the hydrostatic test to be applied to copper pipes shall not exceed one and one-half times the working pressure of the boilers to which they are connected.